

A STUDY ON THE CONTRIBUTIONS OF INDIAN MATHEMATICIANS IN MODERN PERIOD

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Abstract

The objective of this paper is to give a summary of the contributions of Indian mathematicians to a claim about a Diophantine equation in modern times. Vedic literature has contributed to Indian mathematics about 1000 B.C. and the year 1800 A.D. For the first time, Indian mathematicians have drawn up various mathematics treaties, defining zero, the numeral method, the methods of arithmetic and algorithm, the square root, and the cube root. Although, there is a distinct contribution from the sub-continent during readily available, reliable information.

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1. INTRODUCTION

The past of mathematics shows the excessive works, including the mathematical innards of the Vedas of ancient Indian mathematicians. India seems to have made a significant contribution to the simplicity of innovations in the history of mathematics [1]. In addition to the Indians, the entire world is proud that ancient India has made great mathematical accomplishments. In the early stages, two major traditions emerged in mathematics (i) Arithmetical and algebraic (ii) geometric (the invention of the functions of sine and cosine). The position of the decimal number system was its most significant and most influential contribution. However, Indian mathematical history extends much beyond the second half of the 19th century, particularly following the revival of Indian academic life. Major contributions were made by scholars such as Bhramagupta, Bhaskara II, and Varahamira during classical Indian mathematics (400 AD to 1200 AD). First reported in Indian math's the decimal number scheme used today [2].

Indian scientists contributed a great deal in the field of Mathematical Astronomy and significantly contribute to the development of arithmetic, algebra, and trigonometry. Perhaps the most noteworthy developments were in the areas of endless expansion trigonometric terminology and disparity equations. The advent of the decimal counting system is perhaps the most remarkable development in mathematical history. Indians were the first to analyse methods for the determination of integral diophantine equations the typical Indian programming skills have dominated the non-European field in Southern India and were effectively used by Professor Ashok. He wrote a book "Indian Mathematics, an introduction". The knowledge was mostly based on mathematical analysis principles and procedures.

2. HISTORY OF INDIAN MATHEMATICIAN

The first purpose is to keep examples of excellent mathematics in front of us, emphasising the mathematical principles and relationships involved.

A. Old Period**a) Vedic Time (Approximate 3000 B.C. – 1000 B.C.)**

Vedic works include various rules and advances in geometry such as:

- Usage of the geometric forms, containing rectangles, trapezium, triangles, circles, and squares.
- Field and Numbers uniformity
- The difficulty of quadrature of the loop was equivalent and vice versa
- Problems of Pythagoras theorem.
- Approximation for π – Three numerical π values are discovered in Shatapata Brahmana

Vedic works include every four arithmetical operators (addition, subtracting, multiplying, and dividing). This shows that different mathematical approaches were not at that time in a conceptual process but were rather used methodically and extensively.

b) Vedic Post Era (1000 B.C. – 500 B.C.)

Altars had to be created for rituals to be performed. The altar had to be very accurate to be effective with this ritual sacrifice. To make these precise measurements, geometric mathematics has been established. Procedures were accessible in the shape of Shulv Sutras (also Sulbasutras). Shula's lead implies. This lead was used during altar formation for geometry calculation.

i) Jain Mathematics

The development of mathematics is primarily contributed by Jain Acharyas. In Jain's literature, there are extensive math explanations. Jain Mathematics was primarily concerned with:

- Numbers theory
- Operators of arithmetic
- Operations with fractions
- Geometry
- Permutation and Combination
- Simple equations
- Cubic and Quadratic equations

Jains created an infinite theory that included five degrees of infinity: endless in one way, in two directions, in space, endless all over and endless forever. They had a prehistoric knowledge of indices and several notions of base 2 logarithms.

ii) Baudhyayana Sulba Sutras

The fire altar types used in different religious rituals include geometric patterns such as squares, triangles, rectangles etc. The BAUDHYAYANA SULBA SUTRAS provide techniques for changing a square into a rectangle, trapezium, as well as vice versa. It is observed through this procedure that the square on the diagonal of a certain square holds double the initial area [2].

If ABCD be a square of side of determine 'l', about so the area of the square ABCD is provided by l^2 . Then according to the method of the SULBA SUTRAS BAUDHYAYANA.

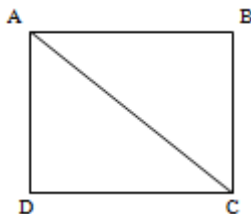


Figure 1: Baudhyayana Sulbha Sutra [2]

$$\begin{aligned} AC^2 &= 2l^2 \\ &= l^2 + l^2 \\ &= AB^2 + BC^2 \end{aligned}$$

$$\text{Or } AC^2 = AD^2 + CD^2$$

Eq. 1

This is called as "Pythagoras' theorem".

Mathematics was also given due consideration by Buddhist literature. The mathematics is divided into two categories:

- Garena (Simple mathematics)
- Sankhyan (Higher mathematics)

Numbers in three categories have been described:

- Sankhya (Countable)
- Asankheya (Uncountable)
- Anant

iii) Bakshali Manuscript

There are eight major topics in the Bakshali script:

- Three rules (profit and loss and attention)
- Linear equation solution of up to five unknowns
- Quadratic equation solutions
- Composite Series

- Geometric and Arithmetic Progressions
- Quadratic Unspecified calculations
- Simultaneous Equations

B. Pre-Mid Period (500 B.C. – 400 A.D.)

Mathematics was also adequately established during this time. The following is the subject of Vaychali Ganit in particular:

- Fractions
- Numbers based on 10
- Basic math calculation
- Interest methods
- Rule of false position
- Squares and Cubes of numbers

C. Mid-Term Classic Period (400 A.D. – 1200 A.D.)

Throughout this era, the way of creating Siddhantas, which began about 500 BC, continual. The Pitamaha Siddhanta is the oldest of the Siddhanta's (about 500 BC) and the most recognized is the Surya Siddhanta (about 400 AD, unknown author, prejudiced Aryabhata). The invention of the sinus mechanism was the key achievement of these works. The setting-up of the "galaxy" of Aryabhata-led mathematician astronomers. Those men were first and foremost astronomers, but astronomers developed many fields of mathematics because of the mathematical criteria of astronomy (and probably of further interest).

D. Classic End (1200 A.D. – 1800 A.D.)

The function of Bhaskara is studied the peak point of mathematics in India, and Indian mathematics has long since ceased. Jagannatha Samrat (1690 A.D.-1750 A.D.) and Kamalakara (1616 A.D.-1700 A.D.) are worth considering for short purposes. Kamalakara gave fascinating trigonometric results and Samrat created both mixing the conventional ideas of Indian astronomy and the principle of Arabic.

The Kerala School of Mathematics

Madhava was the founder of the school. He has found extensions of the power series to sine, cosine, and tangent functions and has created an insignificant calculus for trigonometric functions, polynomials, and rational functions.

The Kerala School was aware of this discovery, which was made decades later by Gregory and Leibniz. It has dubbed it the Madhava–Gregory series in honour of its creators.

Important discovery by Keralese mathematicians contain:

- Sum of an infinite series
- Infinite series
- Newton-Gauss interpolation formula

- Expansions of trigonometric functions

E. Current Period (1800 A.D. Onwards)

Books about trigonometry, numerical mathematics, and geometrical mathematics were published by Bapudev Shastri (1813 A.D.). Books were published by Sudhakar Dwivedi (1831 A.D.) titled:

- Samikaran Meemansa (analysis of equations)
- Golaya Rekha Ganit (sphere line mathematics)
- Deergha Vritta (dealing with ellipse)

Yet, the Indian mathematicians continued to do appreciable work in several branches of mathematics. Some of them were K. Anand Rau (1893-1966), S.S. Pillai (1901-1950), S. Chowla (1907-1995), T. Vijayaraghavan (1902-1955), K. Chandrashekharan (1920-1995), and S. Minakshisundaram (1913-1968) (Seth, 1963). The indigenous interest and achievements in mathematics in the past must have fuelled their urge additionally.

a) Srinivasa Ramanujan

The modern mathematical scholar Srinivasa Ramanujan (1889 A.D.). He went into the Vedic form of writing and then proving mathematical principles. His logically is shown by the fact: some of his fifty theorems have taken many modern mathematicians to prove.

Ramanujan has also shown that it is possible to write any large number as the addition of no more than four prime numbers. It demonstrated how the number could be split into two or more squares or cubes. It is the minimum number that can be interpreted as the sum of two cubes in two various aspects: Author also suggested that 1729 is the nominal figure that can be inscribed in two ways in the system of the addition two cubes' numbers, i.e., $1729 = 9^3 + 10^3 = 1^3 + 12^3$. The digit 1729 has since been named Ramanujan's number [3].

b) Swami Bharti Krishna Tirtha (1884 A.D. – 1960 A.D.)

The book Vedic Ganit has been published by Swami Bharti Krisnateerthaji. He's Vedic Ganit's creator and father. With lexicographic details, the key to the Ganita Sutra encoded in Atharva Veda was obtained by Bharati Krishnaji. He considered "65 sutras," a word that covers all undergrowth of mathematics, geometry, arithmetic, trigonometry, physics, spherical and plane geometry, conical and calculus, and all kinds of applied mathematics varying and precise, complex, hydrostatic, and all kinds of mathematics [4].

c) Shakuntala Devi (1929 A.D.-2013 A.D.)

Shakuntala Devi, the most famous Indian female mathematician ever, was more often called the human-machine. Because of her immense ability, she was named by no calculator to solve equations. Sakuntala Devi published a significant number of mathematics books. She also was the President of India's astrologer. In 1980, in 28 seconds, she gave two thirteen-digit figures and various nations requested her to prove her outstanding ability. She was playing with a PC in Dallas to see who was going quicker the cube root of 188138517! In the US University, the 23rd root of the 201 numbers was demanded. In

fifty seconds, she responded. It took a complete one-minute UNIVAC 1108 to report that she was fed 13,000 instructions directly afterward.

d) Manjul Bhargava (1974 A.D.-2013 A.D.)

The coveted Fields Medal, honoured as the 'Nobel Prize for mathematics' in 2014, was won by a mathematician of Indian descent. A Canadian-American mathematics professor at Princeton University Manjul Bhargava was awarded a Fields Medal for the development of powerful new numerical geometry methods that he used to count small rank rings and connect the average rank of elliptic curves," was awarded a Fields Medal for the development of powerful new numerical geometry methods, which he applied to counting small rank rings and binding the average elliptical curve rank.

The work of Mr. Bhargava in number theory had a profound influence on the field. He has a taste for simplistic problems of timeless elegance that he has solved by creating sleek and strong modern approaches that give profound insights. A mathematical man with exceptional imagination.

The generalization was that if perfect quadrature is the sum of two numbers and each one is multiplied by a perfect square; the result is again the sum of an entire perfect quadrature. The procedure is if unique multiplies two binary square shapes, the rule states which square shapes will emerge. Manjula found that if he put numbers on each of the mini-four cube's corners and cut the cube in half, it will be possible to combine the eight corner numbers to create a binary quadratic form.



Figure 2: Rubik

Indeed, as there are three methods to break the cube in half-make the front-back, left-wing or top-bottom divisions the cube could produce three binary quadratic formats, one found ins Gauss was that it was made up of a binary quadratic form rule, i.e., $ax^2 + bxy + cy^2$, with a, b and c being fixed complete numbers, and x and y are variables.

According to Professor Bhargava, the composition of quadratic forms is not the only one that may be found in other forms, such as cubic. Furthermore, the Gauss composition is just one of at least 14 similar laws that he discovered [5][6].

e) Shreeram Shankar Abhyankar (22nd July 1930 – 2nd Nov 2012.)

He was a mathematician from Indian America. Shreeram Abhyankar has given a large number of significant mathematical contributions, in particular commutative algebra, algebraic geometry the functional theory of numerous complex variables, combinatorics, invariant conceptual. Many books were written by Professor Abhyankar: "Resolution of Singularities of Embedded Algebraic Surfaces," "Ramification Theoretical Methods in Algebraic Geometry.

Presume that $f \in k[X, Y]$ — the polynomial ring is generated by two-variable polynomial with irregularity. This statement is accurate, yet it needs extensive justification. Abhyankar recast it in such a way that it can be understood and discussed by even a middle-level scholar:

Assume $p(t) = t^n + p_1 t^{n-1} + \dots + p_n$ and $q(t) = t^m + q_1 t^{m-1} + \dots + q_m$ are polynomials so that t can be inscribed as a polynomial in $p(t)$ and $q(t)$. Is it factual that n splits m or m splits n ?

He defined a polynomial $f(X, Y)$ to be a “variable” if there is a polynomial $g(X, Y)$. In regular representation, this describes $k[X, Y] = k[f, g]$. The “Epimorphism Theorem” provides an adequate state that there are polynomials p, q as defined beyond so that $f(p(t), q(t)) = 0$ [7].

f) K.S.S. Nambooripad (6th April 1935 – 4th January 2020)

Nambooripad was born in Puttumanoor, near Cochin, in central Kerala, on 6 April 1935. He was a mathematician from India who made a profound contribution to the structural theory of regular semigroups. He initiated his investigate livelihood running in investigation and figure theory. Nambooripad's has contributed significantly to our understanding of the structure of ordinary semigroups.

The definition of a periodic bordered set is one of his fundamental principles. If f and e are idempotents of a semigroup S like $ef = e$ then the result of is additional S idempotent, it is easy to see. Such products are referred to as essential products by Nambooripad. Equally, a bordered set of a normal semigroup S is characterized axiomatically as the set $E(S)$ prepared with the two quasiorders ω^r and ω^1 (defined by $e \omega^r f$ iff $fe = e$ and $e \omega^1 f$ iff $ef = e$) along with conversions linked to these quasiorders that allow us to describe the elementary products. Its axiomatic classification is inherent to $E(S)$ in far the similar manner that it is possible to define the inverse semigroup idempotents as a (lower) semilattice.

The idea of a bordered set of Nambooripad can be seen as a substantial simplification of the concept of a semilattice. If S is a semigroup and $e, f \in E(S)$, then it is possible to describe,

$$S(e, f) = \{h \in E(S) : he = h = fh, ef = ehf\}. \quad \text{Eq. 2}$$

Suggestion that if f and e are consistent semigroup S idempotents, then $S(e, f) = \emptyset$. Indeed if $(ef)'$ is an inverse of ef in S , then the $h = f(ef)'e$ element is in $S(e, f)$ [8].

3. MODERN METHODOLOGIES USED:

A. Number Theory- Mathematical study of integer functions, or arithmetic, is the focus of number theory, which is a branch of pure mathematics. Primary numbers and integer features of mathematical ideas defined as generalizations of the number are studied by number theorists (such as, algebraic integers). The previous term for number theory is algebra. One of the most contentious characteristics of current numerals in math is the point fraction number system that serves as its root. The philosophy of numbers had been surpassed by the early 20th century.

- **Algebraic Number Theory-** it is a subfield of mathematics that use conceptual algebra techniques to examine the fundamental, rational numbers, and their generalisation. Numerous mathematical difficulties arise when algebraic objects' properties.

- **Probabilistic Number Theory**-The study of generally not always independent variables reveals various probabilistic number-theory concepts. For instance, it is almost irrelevant whether or whether an arbitrary number among 1 million. Occasionally, it is assumed that probabilistic combinative mechanisms make use of the fact that everything occurs by a better probability than it must happen occasionally.

B. Infinite Series-In contemporary language, every infinite composition of numbers denotes a series, which is the method of adding a_i one after the other. To emphasise the infinite number of possible terms, a sequence can be referred to as an infinite sequence. A phrase such as is used to represent (or signify) such a series,

$$a_1 + a_2 + a_3 + \dots, \quad \text{Eq. 3}$$

or, utilizing the summation indicate,

$$\sum_{i=1}^{\infty} a_i. \quad \text{Eq. 4}$$

A series represents an infinity of additions that can never be completed (at least in a finite amount of time). A series number may be assigned to a collection of phrases and their finite additions when there is a concept of a limit in the set they belong to. n th biased series sums have a finite sums limit that approaches infinity as the n th term of the sequence approaches infinity (if limit occurs),

$$\sum_{i=1}^{\infty} a_i = \lim_{n \rightarrow \infty} \sum_{i=1}^n a_i. \quad \text{Eq. 5}$$

Basic Properties

An infinite sequence is a collection of infinite numbers described by an infinite type as,

$$a_0 + a_1 + a_2 + \dots, \quad \text{Eq. 6}$$

where (a_n) is a functions, numbers, or anything else that may be added to an orderly succession of words (a group of abelian). By positioning them next to each other and putting the "+" symbol next to them. One may also express a series using summation notation $\sum_{n=0}^{\infty} a_n$.

The series number of a convergent series is A . For example, an Abelian group A of elements can be defined as a real digit field. Certain a sequence $\sum_{n=0}^{\infty} a_n$, its k th biased addition is

$$s_k = \sum_{n=0}^k a_n = a_0 + a_1 + \dots + a_k. \quad \text{Eq. 7}$$

The sequence $\sum_{n=0}^{\infty} a_n$ converges to the edge L if the sequence of its subjective amounts has a limit L . Then L ,

$$L = \sum_{n=0}^{\infty} a_n. \quad \text{Eq. 8}$$

If a sequence is converging to around limit, it is said to be converging; otherwise, it is said to be diverging.

C. Representation theory of quadratic forms- algebraic structures may be represented as linear transformations of vector spaces in the Theory of Representation [1]. As a concreter way of expressing an abstract mathematical entity, such as via algebraic operations or matrix multiplication. Matrices and Linear operators are well-known concepts, which aids in gleaning characteristics and also simplifies calculations for more complicated theories defined in terms of basic linear algebra objects. Using the Theory of Representation, algebraic issues may be reduced to the simpler linear algebraic form.

D. Algebraic Geometry- algebraic geometry has focused on the zeros of polynomials. Algebraic geometry is based on the employment of commutative algebra in the resolution of intellectual algebraic methods. Complex analysis, topology, and count theory all have a strong connection to algebraic geometry in contemporary mathematics. Beginning with polynomial equation systems in numerous variables, algebraic geometry starts to focus on their fundamental qualities, rather than a single solution to a specific problem. In both conceptual and conceptual terms, this contributes to some of mathematics' most significant domains.

E. Regular semi groups- every item in the semigroup S must be systematic or regular, such as the existence of a component x that is equal to every single component a in the semigroup S . Regular semigroups are the most prevalent kind of semigroup class.

A regular semigroup S may be described in two ways that are connected to one another:

- A pseudoinverse ($axa = a$) exists for every x in S . This is called an x in S .
- All components a has a minimum one opposite b , in the idea that $aba = a$ and $bab = b$.
- To find the similarity of these explanations, initially presume that S is specified by (ii). Then b operates as the requisite x in (i).
- Similarly, if S is described by (i).
- xax is an inverse for a , since $a(xax)a = axa(xa) = axa = a$ and $(xax)a(xax) = x(axa)(xax) = xa(xax) = x(axa)x = xax$.

In the preceding reasoning, $V(a)$ denotes the inverses set of a component in a S . (arbitrary semigroup) [9]. According to this, a non-empty normal semigroup may be described as $V(a)$ for each a in S . All of the elements in the $V(a)$ have the same product in the $V(a)$ of idempotence.

Examples Of Regular Semigroups

- All bands are regular (idempotent semigroup).
- The regularity of the bicyclic semigroup.
- It's common for each group to have a semi-group.
- A regular semigroup's homomorphic image is standard.
- The semigroup of a Rees matrix is logical.
- Some done transformation semigroup is logical.

4. DISCUSSIONS

Trigonometry methods, arithmetic, algorithms, squares, cube roots, negative numbers, and the most important decimal method are principles discovered and used worldwide by an ancient Indian mathematician. The Indian mathematicians contributed over several thousand years to very significant developments in mathematics. Although the development of Indian mathematics is significant, it is not distributed to the degree that the expertise and understanding are due to many other mathematicians. The analysis of indeterminate equations is a matter on which all of these mathematicians contributed

profoundly (similarly known as “Diophantine equations”). In this case, the goal is to find integer solutions to a polynomial equation with integer coefficients, not simply rational ones. In reality, Diophantus had studied solutions of Equations in Rational Number (not integers) - rational equation solutions are of important geometric significance the integer solutions of a polynomial equation with integers (not just rational solutions). Diophantine equations are usually contained in a polynomial equation in several unknowns (an entire solution that takes integer values for all unknowns) in mathematics [9]. An exponential Diophantine equation is an exponent of unknown terms Since the individual equation contains something like a puzzle considered throughout history, it is the achievement of the twentieth century to formulate the general theories of Diophantine equation (above the theory of quadrilateral forms). Divakaran has researched the continuing effects on Indian mathematics of recursion and claims that it is one of Indian mathematics' key features. The brilliant mathematician Sri Srinivasa Ramanujan was inspired by the extraordinary breakthroughs in mathematics made in the 18th century. Srinivasa Ramanujan was the twentieth century's greatest mathematician. Ramanujan and the contributions of other mathematicians were part of world mathematics.

5. CONCLUSIONS

The principal purpose of this paper is to provide the development of Indian mathematics during ancient, medieval, and modern times with chronological order. In many mathematical fields in the 20th century, Indians contributed significantly. However, in the course of the 17th to 19th centuries Indians were practically not interested in the rapid growth of mathematics the general stagnation in national life. Although secondary school mathematics, particularly in arithmetic and algebra, is mainly Indian, the majority of these mathematics were developed in Indian courses in the late 17th and early 20th centuries. The Indian math scenario has now developed to higher levels. Several mathematicians have contributed enormously, and study continues relentlessly to the field of mathematics.

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